Ponderosa Pine Risk Rating School
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SOME FACTS ABOUT PONDEROSA PINE RISK RATINGS FOR WESTERN PINE BEETLE CONTROL

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The economy of the Inland Empire[1] is closely associated with the continued production of its forests. Foresters and lumbermen alike have come to realize, however, that sustained production is not altogether a problem of balancing the cut with the growth. The conversion of extensive mature and overmature forests to a state of continuous production necessarily is a long-time procedure because of the more or less fixed milling and marketing conditions. During this time such factors as fire, insects, disease, or wind may upset the procedure. This is particularly true in the case of the Empire's extensive ponderosa pine forests, recently estimated (4) to contain about 20 billion board feet. Most of this timber has been ready for harvest for many years, yet it will be a good many more years before it can be utilized. In the meantime it is, and will continue to be, vulnerable to attacks of the western pine beetle (Dendroctonus brevicomis Lec.) an insect which has caused serious depletion in many ponderosa pine stands from time to time.

The problem of protecting these reserve stands of overmature pine from the ravages of this beetle was greatly simplified by the adoption in 1937 of a method of telling which trees were currently susceptible to attack. This is done by employing a risk rating system developed in that year in California. The system was made possible by capitalizing on the findings of a long series of studies which indicated that the western pine beetle normally chooses to attack the less vigorous ponderosa pine trees in a stand. By arbitrarily setting up several degrees of vigor, as evidenced by certain crown characters, and determining their incidence of attack, it was possible to establish a more or less definite degree of susceptibility, or risk, for each tree.

The risk ratings are the basis of subsequently developed "Sanitation-salvage" cuttings designed to reduce timber losses resulting from the attacks of the western pine beetle. This type of cutting removes from 10 to 30 per cent of the pine in trees particularly susceptible to beetle attack. The remainder of the stand consequently is "bug-proofed" by the removal of these high-risk trees, since they are the ones most frequently attacked and in which epidemic-causing populations of the beetle are bred. Furthermore, the cutting allows these trees to be fully utilized before they are killed.

The details of the risk rating system and its application have been published elsewhere (3). Briefly, it segregates individual ponderosa pine trees of all ages into one of four ratings, each representing a different degree of tree vigor. This is done by combining variations in such tree-crown characters as top density, top needle length, needle color, twig injury, and top killing. These characters are easily observed and even the novice can soon learn to evaluate them. Studies conducted in California since 1937 have indicated a definite index of attack for each of the four risk ratings Risk-1 trees, for example, are seldom attacked by the western pine beetle, unless mechanically injured in some way. They are called low-risk trees. Risk-4 trees, on the other hand, are normally very highly

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1. Stevens, Pend Oreille, and Spokane Counties, Washington; Idaho north of the Salmon River; and Montana west of the Continental Divide.

susceptible to attack. Risk-3 and Risk-4 trees together are termed high-risk trees. Except during extreme epidemic conditions they make up about 85 per cent of trees attached under conditions that prevail in California, Oregon, and Washington east of the Sierra Nevada-Cascade Range.

Because the crown characters used in delineating risk respond in a short time to abrupt or prolonged changes in environment, particularly seasonal precipitation and air temperature, they are of value only in indicating the current vigor, or risk rating, of a tree. For this reason the ratings applied to trees are believed to be good only for about 10 years. This period conceivably may be lengthened if the environmental conditions at the end of 10 years have not changed to effect a decline in tree vigor or a build-up in beetle populations.

DESCRIPTIONS OF RISK RATINGS FOR PONDEROSA PINE

The characters used in defining risk are concerned only with the apparent vigor of the crown as evidenced by the foliage, twigs and branches. Factors of age, crown form and crown position do not enter into the appraisal of risk from insect attack.

In the following descriptions, risk has been tentatively segregated into four groups. These four groups have been established primarily to provide sufficiently small gradations to allow for variation in application in selective logging practice. Where the prevention of insect loss in the near future is the primary objective, either the highest risk group alone (Risk 4) or the two highest risk groups (Risks 3 and 4) may be removed. Where utilization cuts are desired, material from the moderate and high risk groups might be supplemented with trees that are cut for silvicultural or economic reasons.

Descriptions of Risk Ratings

RISK I. LOW RISK

Full foliaged, healthy appearing crowns. Foliage of healthy appearance, needles usually long and coarse, color good dark green. Practically all twigs with normal foliage complement. No weakened portions of crown.

RISK II. MODERATE RISK

Fair to moderately healthy crowns, imperfect in spots, Foliage mostly healthy, needle length or better, color fair to good. Some twigs or branches may lack foliage, but such injury should not be localized to form definite "weak" spots in crown.

RISK III. HIGH RISK

Crowns of fair to poor health, somewhat ragged or thin in portions of crown. Foliage in parts of crown thin, bunchy, or unhealthy, needles average to shorter than average in length, color fair to poor. Some to many twigs or branches lacking foliage, some to many twigs or branches fading or dead. Small localized weakened portions of crown usually present.

RISK IV. VERY HIGH RISK

Crowns in poor condition, ragged or thin, often showing evidence of active insect infestations in upper portions. Foliage thin or bunchy, needles short or sparse, color poor. Twigs and branches dead or dying, portions of crown definitely weakened. Active topkilling or partial infestations often present.

Some types of tree injuries are not associated with a normal rating of risk. They may be the result of accident, such as lightning or mechanical injury, and when such injuries affect the immediate risk of infestation and early death they should be appraised independently of the characters given above for rating risk. In addition, the following tree characters are not considered to be primarily concerned with current risk.

Branches. Upturned near top, middle crown horizontal, lower ones drooping; moderately large for size of bole.

Top. Usually pyramidal or rounded, occasionally pointed; whorls indistinct except at extreme top.

Age Class 4. Overmature trees. Making no further height growth; diameter growth very slow; age more than 300 years.

D.b.h. Wide latitude in diameters, but usually large in dominant trees.

Height. Full height of general crown canopy; except suppressed, spike-topped, or broken trees.

Bark. Light yellow and uniform for entire bole, except in extreme top; plates usually very wide, long, and smooth; fissures often rather shallow.

Branches. Large, heavy limbs, often gnarled or crooked; mostly drooping except in extreme top.

Top. Usually flat; occasionally rounded or irregular.

The distinction between age classes 1 and 2 is based largely on color and roughness of bark as well as character of branching. While both are sometimes called "bull pines" or "black jacks," only class-1 trees have the rough, black bark for practically the entire length of the bole; and upturned branches in distinct whorls, so characteristic of young, juvenile growth. Class-2 trees have this dark, rough bark in the upper half of the bole, but the bark on the lower half is turning red and developing narrow plates on the ridges, particularly on the south side.

The distinction between age classes 2 and 3 is mainly a matter of height, character of the bark, and branching in the upper part of the tree. Class-2 trees are understory trees somewhat less than 90 per

cent of the height of the general crown canopy, whereas class-3 trees have practically reached the height of the general crown canopy and only show dark bark and upturned branches in the upper quarter of the crown.

The distinction between age classes 3 and 4 is more difficult to recognize, since there is no sharp line of demarcation between a mature and an overmature tree. Light colored bark for practically the entire bole, absence of dark bark on the bole except at the extreme top, and large heavy limbs, mostly horizontal or drooping, are the principal distinguishing features of overmaturity.

In the field, age classes of dominant and codominant trees are fairly distinctive. Suppressed and intermediate trees in the older-age classes often cause more difficulty, since their diameters are small and they frequently simulate the characters of younger trees. Since ponderosa pine usually grows in even-aged groups, the age class of the surrounding trees will usually give a clue to the age of suppressed individuals in the group.

Table 2. A COMPARISON OF SOME RELATIONSHIPS BETWEEN LOW AND HIGH RISK PONDEROSA PINE TREES

	Top Crown		Mid-Crown		Lower Crown	
	Risk 1	Risk 4	Risk 1	Risk 4	Risk 1	Risk 4
Number of needle fascicles per twig	197.4	119.1	188.1	108.8	173.9	
Needle length, inches	6.2	4.9	6.5	5.0	6.6	
Needle diameter, mm.	1.87	1.80	1.86	1.76	1.80	
Annual twig growth, 1917-40, inches	.80	.58	.72	.57	.70	
Twig diameter, cm.	1.52	1.23	1.38	1.10	1.32	
Annual radial stem growth 1912-41, inches	.013	.011	.021	.011	.014	.013

Table 3. DISTRIBUTION OF GREEN AND BEETLE KILLED PONDEROSA PINE TREES, BY RISK CLASSES

Risk Class	No. of Trees	Volume of Trees M b.m.	Volume of Trees Per cent	Mortality Ratio
		GREEN TREES		
1	17,254	12,176	54.4	
2	5,624	6,531	29.2	
3	1,614	2,001	8.9	
4	1,368	1,668	7.5	
TOTALS	25,860	22,376	100.0	
		BEETLE KILLED TREES		
1	34	25	5.2	0.1
2	52	51	10.5	0.4
3	65	82	16.8	1.9
4	253	327	67.5	9.0
TOTALS	404	485	100.0	

Table 4. CUMULATIVE REDUCTION IN BEETLE CAUSED PONDEROSA PINE MORTALITY FOLLOWING SANITATION SALVAGE CUTTINGS AT BLACKS MOUNTAIN EXPERIMENTAL FOREST, LASSEN COUNTY, CALIFORNIA[1]

Period Following Cutting	Natural Mortality b.m./ac.	Mortality After Cutting b.m./ac.	Average Reduction in Mortality b.m./ac.	Per cent
1-year	73.0	10.2	62.8	86.1
2-year	140.6	18.6	122.0	86.8
3-year	194.8	23.8	171.0	87.8
4-year	277.2	32.8	244.4	88.2
5-year	333.8	40.6	293.2	87.8
6-year	367.3	43.7	323.6	88.1
7-year	453.1	52.9	400.2	88.3
8-year	578.1	64.5	513.6	88.8
9-year	853.4	111.8	741.6	86.9
10-year	556.7	163.0	393.7	70.7

1. From Bongberg (1)

Table 5. OCCURENCE OF RISK 3 AND RISK 4 TREE VOLUME IN COMPARABLE STANDS OF MATURE PONDEROSA PINE

Location	Total Stand Volume b.m./ac.	Risk-3 and Risk-4 Trees Volume b.m./ac.	Per cent of Stand
Montana:			
Kootenai River	15,574	2,620	17
Fischer River	30,026	3,442	12
Blackfoot River	15,870	3,310	21
Deep Creek	11,200*	3,113	35
California:			
Blacks Mountain Experimental Forest	17,380	2,774	16

*Estimated

References

1. Bongberg, Jack W. 1950.
   Results of 10 years of bark-beetle control by logging high risk trees. Blacks Mountain Experimental Forest, Lassen County, California. U.S.D.A. Forest Insect Laboratory, Berkeley, California. Laboratory Report. (Processed.)

2. Keen, F. P. and Salman, K. A. 1942.
   Progress in pine beetle control through tree selection. Jour. Forestry 40: 854-858.

3. Salman, K. A., and Bongberg, J. W. 1942.
   Logging high-risk trees to control insects in the pine stands of northeastern California. Jour. Forestry 40: 533-539.

4. U. S. Forest Service. 1946.
   Gaging the timber resource of the United States. Report No. 1 from a re-appraisal of the forest situation. 62 pp. (Processed.)

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PONDEROSA PINE TREE CLASSES REDEFINED

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The ponderosa pine tree classification developed by the writer[1] for determining susceptibility of ponderosa pines to bark beetle attack has been used in this region for timber-marking purposes and for insect mortality and growth studies during the past 6 years. It has also been adapted by Hornibrook[2] to fit conditions found in the Black Hills of South Dakota and Wyoming and by Thomson[3] for application in the Southwest. In practical field use the need has arisen for more exact definitions and a weighting of the more important factors, in order to obtain closer standardizing of interpretation and to iron out such ambiguities as existed in the original descriptions.

Following a recent study of 3,700 trees as to growth rates, crown characteristics, and susceptibility to bark beetle attacks, new definitions have been prepared. Whereas no change has been made in the average criteria for any tree class, these new definitions should make possible an improvement in the classification of borderline trees so as to place them in the class most nearly representing their respective growth rate and mortality risk. The revised descriptions of the tree classes are as follows:

REVISED DESCRIPTION OF TREE CLASSES

The two primary factors on which this tree classification is based are age and crown vigor. Each of these factors is subdivided into four parts, making a total of 16 tree classes. Although four age groups and four crown-vigor subdivisions can be recognized in any ponderosa pine stand, the tree characteristics which differentiate the age or vigor groups vary considerably in different parts of the pine region and on different sites, and hence cannot be described specifically, except for a particular site and for limited portions of the region. Thus the following descriptions apply primarily to

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1. Keen, F. P. 1936 Relative susceptibility of ponderosa pines to bark beetle attack. Jour. Forestry 34: 919-927, illus. October.
2. Hornibrook, E. M. 1939. A modified tree classification for use in growth studies and timber marking in Black Hills ponderosa pine. Jour. Forestry 37: 483-488, illus. June.
3. Thomson, Walter G. 1940. A growth rate classification of southwestern ponderosa pine. Jour. Forestry 38: 547-553, illus. July.

average Site IV in central and southern Oregon and northeastern California. Hornibrook has given the corresponding descriptions for the Black Hills ponderosa pine, and Thomson has described the characteristics of similar age and vigor groups in the Southwest. Other modifications will be needed to fit conditions in other regions, but the general principles are the same anywhere.

CROWN-VIGOR CLASSES

It is a well-recognized silvicultural principle that the growth rate of trees for a given site and age class is directly proportional to the size of crown or area of leaf surface.[4] Therefore, in this classification each age class is subdivided into four divisions based on size of crown, and abundance of foliage. These subdivisions, grouping together trees of similar growth capacities, indicate four degrees of relative crown vigor and are designated A, B, C and D from best to poorest.

In the study of growth rate of trees in relation to crown characteristics, the following factors, in order of their importance, were found to be the best outward indicators of crown vigor and inherent growth capacity.

(1) Size of crown - length, width, and circumference.
(2) Density of crown.
(3) Form of top - pointed, round, flat, or spiked.
(4) Location of crown on the bole.
(5) Position of tree - isolated, dominant, codominant, intermediate, or suppressed.

Apparently in uneven-aged stands, such as open-grown ponderosa pine, the size and density of a tree's crown usually reflects the tree's position as to dominance or light and the amount of root competition.

In defining the four crown-vigor classes, it is impossible to describe all the variations in crown shape which may be encountered. Crown size and density are the principal criteria, and typical trees of crown-Class A which might be considered as the ideal outline, may be used as a standard of comparison. In the following descriptions it should be understood that other shapes may still belong to that crown-vigor class, provided the total volume of crown comes within the established limits.

The crown-vigor classes are defined below, and their descriptions are given in condensed form in table 2.

A - Full Vigor

Crown. Full vigorous crowns with a length of 55 per cent or more of the total height, and of average width or wider;

4. Dunning, Duncan. 1922. Relation of crown size and character to rate of growth and response to cutting in western yellow pine. Jour. Forestry 20: 379-389. April

with density average or better for its age class.

Foliage. Needles of average length or longer, usually dense and thrifty.

Position. Usually isolated or dominant; rarely codominant.

D.b.h. Large for age.

B - Good to Fair Vigor

Crown. Good to moderately vigorous crowns, with length from 30 to 55 per cent of total height, if of average width and density; or a longer crown if narrow or somewhat thin; but neither sparse nor ragged.

Foliage. Needles of average length, usually dense and thrifty.

Position. Usually codominant, but sometimes isolated or dominant; rarely intermediate.

D.b.h. Average or above for age.

C - Fair to Poor Vigor

Crown. Fair to poor crowns, with length from 10 to 30 per cent of total height if of average width and density, or long, sparse, and narrow; often flat on one or more sides.

Foliage. Needles often short and thinly distributed, but of normal length and density when confined to top one-third of crown.

Position. Usually intermediate, sometimes codominant or suppressed, but rarely isolated.

D.b.h. Usually below average for age; sometimes large in decadent trees.

D - Very Poor Vigor

Crown. Very short, less than 10 per cent of the total height; sometimes merely a tuft at top of tree, or somewhat longer when sparse and ragged; usually very narrow or limbs all on one side.

Foliage. Needles often short, and foliage sparse or scattered, or only tufts at end of twigs; but of normal length and density if reduced in quantity.

Position. Usually suppressed or intermediate, but may occupy other positions if greatly reduced in vigor.

D.b.h. Decidedly subnormal for age, but very old, decadent trees may be of large diameter.

Current tree health

The present tree classification is primarily concerned with the relative maturity and inherent vigor or growth capacity of different classes of ponderosa pine. The factors, such as diameter, crown-size, position, and general thrift, on which these classes are based, change but slowly over a period of years. In addition, there is the matter of current tree health which must be taken into consideration. For any tree, regardless of class, may become weakened or sick from such causes as deficiency of available moisture or food supply, root injuries, the debilitating effects of fire, insect attack, disease, or other pathological conditions. The symptoms of poor health may be evidenced by decadence or dying of the top, shortening and thinning or poor color of the foliage, or the presence of dying twigs on portions of the crown. These symptoms of current tree health form the basis of Salman and Bongberg's[5] system of rating risk, and it is recognized that they may change rather rapidly from year to year.

The tree class designation thus indicates maturity growth capacity, and beetle susceptibility over a relatively long period of time. The additional appraisal of current tree health may be used to indicate for individual trees their risk of bark beetle attack over the next few years. Both appraisals are needed in marking ponderosa pine on a selective basis, if future loss from beetles is to be avoided.

Stag Tops: An old bare spike, which is the result of an old topkilling injury from which the tree has recovered, is termed a stag top. Although a deterioration of the remaining crown often follows below stag tops and such trees may be rated as high risks, the stag top alone is not considered a character of high risk. When the remai ing parts of the crown are vigorous and healthy, such trees can be considered low risks.

Mule Tail Foliage: In some trees the foliage has a distinctly bunchy appearance though the needles are long. This condition seems to be due to a peculiar development of the branches and apparently is a normal characteristic of a certain strain or type of pine tree. Other things being equal, it should be ignored in rating risk.

Off Color Due to Cold: In certain years and locations needles may be browned due to the effects of low temperatures. Light, local or generalized light browning of needles is not usually considered in rating risk. However, in some areas cold injury has been so severe as to cause a cambium injury in addition to a foliage injury. Severe injuries may have a considerable effect on the current risk from insect attack.

Cone Fade: Often, in seed years, needles behind the cones die and fade. Apparently this fading has no relation to risk.

Natural Needle Fall: During the fall months of the year, the normal fading of old needle complements may create an appearance of high risk. However, this needle fall is natural and the seasonal condition should not be counted as a factor in determining the risk of individual trees.

5. Salman, K. A., and Bongberg, J. W. 1942. Logging high-risk trees to control insects in the pine stands of northeastern Calif. Jour. Forestry 40: 533-539.

Natural Shading out of Branches: On most trees in a fairly closed canopy the lower branches lose their foliage and die. Such natural shading out of branches does not indicate high risk. This must be differentiated from the dying of twigs and branches in the upper, unshaded parts of the crown, a condition which is considered a definite indication of high risk from insect attack.

In stands and in individual trees there apparently are no clearly marked steps in the change, over time, from a resistent to a susceptible condition or from a vigorous to a weakened condition. Those changes are marked by the appearance of no definite single character that can be used for all trees. Usually several or different evidences of deterioration develop in different trees. Some appear to be more particularly concerned with the early stages of deterioration while others may be more closely connected with the later stages.

Table 1. IMPORTANCE OF CROWN FACTORS IN RISK CLASSIFICATION

Crown Factor		Per cent of Green Trees (979)	Per cent of Infested Trees (58)	Ratio of Mortality
Top Crown Density:	Dense	86	16	0.18
	Thin	14	84	6.04
Top Needle Length	Long	86	33	0.38
	Short	14	67	4.81
Needle Color:	Dark	60	9	0.14
	Light	40	91	2.98
Twig Injury:	Light	79	12	0.15
	Severe	21	88	4.09
Branch Injury:	Light	85	28	0.33
	Severe	15	72	4.81
Top-Killing:	Absent	91	62	0.68
	Present	9	38	4.41

TABLE 2. CROWN VIGOR CLASSES

Character	Class A	Class B	Class C	Class D
Crown vigor:	Full, vigorous	Good to fair	Fair to poor	Very poor
Crown length:	Long, 55% or more of total height; or less only if more than average width	Average length, less than 55% of total height (approximately 30% to 55% if full and wide) or a longer crown if narrow or somewhat thin	Short (from 10% to 30% of height, if crown of normal density) or long, sparse, and narrow	Very short (less than 10% of total height) sometimes merely a tuft at top of tree, or somewhat longer when sparse and ragged
Crown width:	Usually average width or wider (narrower if very long and dense)	Usually average width or narrower; may be flat on one side	Usually narrow or flat on one or more sides	Usually very narrow and sparse, or limbs all on one side
Crown density:	Usually full and dense or of medium density if longer than 55%	Usually of full to medium density, nor sparse or ragged	Often sparse and ragged except at very top	Sparse and ragged
Foliage:	Needles of average length or longer, usually dense and thrifty	Needles of average length, usually dense and thrifty	Needles often short and thinly distributed, but of normal length and density when confined to top one-third of crown	Needles often short; foliage sparse or scattered or only partially developed, but of normal length if reduced in quantity
Position:	Usually isolated or dominant, rarely codominant	Usually codominant; sometimes isolated or dominant; rarely intermediate	Usually intermediate; sometimes codominant or suppressed, but rarely isolated or dominant	Usually suppressed or intermediate, but may occupy other positions if greatly reduced in vigor
Diameter:	Large for age	Average or above for age	Usually below average for age; sometimes larger in decadent trees	Decidedly subnormal for age, but very old, decadent trees may be of large diameter

Note: The descriptions apply to the usual types of trees found in each class; where exceptions occur, the size of living crown and amount of foliage are the primary considerations in determining the vigor class.